GIGANTISM IN NICOTIANA TABACUM AND ITS ALTERNATIVE INHERITANCE

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INTRODUCTION

WITHIN recent years observers working with different varieties of *Nicotiana tabacum* grown commercially in the United States and elsewhere have recorded the sudden appearance of occasional giant plants of abnormally high leaf number. Except in height and number of leaves, which may be increased several times above the usual number, these giant plants in general appearance do not depart widely from the varietal type from which they took their origin. The great increase in number of leaves, together with a greatly elongated main stem, is accompanied by a period of vegetative vigor of such long duration that blossoming does not normally take place when the plants are growing in the field. In order to obtain seed from such plants, the usual practise has been to transplant the roots and stub, or even the plants entire, to the greenhouse in the fall, where vegetative vigor is resumed with the final production of normal blossoms and seed during the winter. Plants of this habit of growth have been recorded in the Sumatra, Maryland, Cuban and Connecticut Havana types of tobacco.

OCCURRENCE OF GIGANTISM IN DIFFERENT VARIETIES

The first published record of gigantism in tobacco appears to have been made in 1905 by Hunger (1905), working with tobacco in Sumatra in connection with an investigation of the mosaic disease.

Garner (1912) mentioned a Maryland Mammoth type, the origin of which was associated with a cross between two common varieties of Maryland tobacco.

Hayes and Beinhart (1914) reported the occurrence of

giant plants in the Cuban shade tobacco and the Connecticut Havana type in Connecticut.

In addition to Hunger's observation previously mentioned, Honing (1914) brought out other interesting facts concerning the occurrence and behavior of giant plants in Sumatra (Deli) and Java.

Hayes (1915) further discussed the occurrence of giant plants in the Cuban and Connecticut Havana types of tobacco grown in New England.

Hunger, in the paper referred to, states that the largest giant plant observed by him developed 123 leaves and reached a height of nearly five meters. These plants were entirely sterile, or, if blooming took place, the number of blossoms was greatly reduced. Honing states that the behavior of these giant Sumatra plants with respect to the transmission of their peculiarities is variable. In one instance he observed that a line of these plants finally disappeared entirely. With respect to number of leaves, Honing's studies of the Deli tobacco indicates that several more or less distinct types exist. Even though line selections of these have been grown under bag for several generations, plants possessing high leaf number have occasionally appeared. Mammoth plants have also appeared in the Sumatra variety grown in the United States from seed obtained from Sumatra. In 1912 two plants of this type appeared in a plot of about 100 plants grown at Arlington, Va. These plants appeared in the second year's planting from seed obtained from Sumatra. One of these, when removed to the greenhouse, had reached a height of eleven feet and had produced about 100 leaves, with no indication of blooming. It was not possible to determine to what extent these plants transmitted their characteristics to their progeny since both died after being cut back and removed to the greenhouse.

In 1906 and 1907 giant or mammoth plants were obtained in Maryland tobacco, as mentioned above.[1] The

[1] A discussion of the commercial value of these types of Maryland tobacco will be found in Bulletin 188, of the Maryland Agricultural Experiment Station, entitled, "Types and Varieties of Maryland Tobacco," by W. W. Garner and D. E. Brown, 1914, pp. 135–152.

type known as the Broadleaf Mammoth was first observed in 1906 in a selection line of Maryland Broadleaf begun in 1904. Of 100 plants grown in 1906, five were typical mammoth plants producing many leaves and showing no tendency to bloom at the end of the season. Subsequent generations of these plants were grown successively in 1907, 1908 and 1909, and all reproduced the characteristic habits of growth of the original parent isolated in 1906. This mammoth type, as the name indicates, differed materially in shape of leaf from the better known Narrowleaf Mammoth.

The so-called Narrowleaf Mammoth appeared in 1907 in second generation plants of a cross made in 1905 between a Broadleaf type and a Narrowleaf type of Maryland tobacco. From a single mammoth plant found in 1907, 157 plants were grown in 1908, all of which were mammoth plants. Two of these plants which were allowed to grow until frost without topping had produced 109 and 111 leaves, respectively, with no indication of blooming. The Narrowleaf Mammoth has been propagated from seed and grown on a commercial scale in Maryland up to the present time, and under normal field conditions still retains its characteristics of high leaf number and the non-blooming habit.

A third mammoth type appeared in 1907 in second generation plants of a cross made in 1905 between Maryland Broadleaf and the White Burley variety of Kentucky. In a crop of 30,000 to 40,000 plants but one mammoth plant was found. Unfortunately, this plant was harvested inadvertently by laborers and lost.

From the previous discussion it is evident that gigantism has occurred rather widely in the varieties of *Nicotiana tabacum*. It would appear from Honing's work that Mammoth Sumatra plants are not constant in their inheritance and that intermediate forms exist. The accumulated experience of various observers working with all Mammoth types which have appeared in the United States, however, has shown a constant inheritance of

Mammoth characteristics from generation to generation. Intermediate forms have not been observed.

Behavior of Gigantism in Crosses

Since Mammoth forms are now grown commercially in the United States and promise to become valuable new varieties, it has been considered desirable to determine the possibility of combining the Mammoth character of indeterminate growth or gigantism with other characters of commercial value by crossing Mammoth types with ordinary varieties.

The Maryland Narrowleaf Mammoth has been crossed with a number of pure lines of the more distinct varieties of *Nicotiana tabacum,* including White Burley, Yellow Pryor, Little Oronoco, Connecticut Broadleaf, and the very distinct variety known as *N. Chinensis* (S. P. I., No. 42,355). In all these crosses the Mammoth characteristic behaves as a unit character and is recessive to normal size and normal blossoming habit of the ordinary varieties.

A Maryland Mammoth and a Burley Mammoth, secured as the result of the cross Maryland Mammoth ♀ × White Burley ♂, have also been crossed with the distinct species, *N. sylvestris* and *N. glutinosa.* In these crosses the F_1 plants invariably have blossomed normally as where crosses were made with varieties of *N. tabacum.*

Under normal field conditions, first generation plants of all Mammoth crosses have blossomed in practically the same period required by the ordinary varieties of *N. tabacum.* The plants, however, are usually somewhat taller and, on an average, produce a somewhat higher leaf number than the ordinary varieties, showing that the F_1 plants are more or less intermediate between the normal and the Mammoth parents. This relation of leaf number is shown in Table I.

In crosses between Little Dutch and Maryland Mammoth, the F_1 plants were also somewhat larger and produced more leaves than the Little Dutch parent. F_1

TABLE I

COMPARISON OF NUMBER OF LEAVES OF F_1 PLANTS OF CROSSES BETWEEN MARYLAND MAMMOTH AND NORMAL VARIETIES

Variety	Leaf Number Classes									
	23	25	27	29	31	33	35	37	39	41
Yellow Pryor	2	7	1							
Md. Mammoth ♀ × Yellow Pryor ♂			1	1	1	6	7	2	2	
Little Oronoco	1	1	2	3	3					
Md. Mammoth ♀ × Little Oro. ♂					1	3	2	11	4	1
White Burley	1	4								
Md. Mammoth ♀ × White Burley ♂						1	6	10	5	1

plants of the cross Maryland Mammoth ♀ × *N. Chinensis* ♂ (S. P. I., 42,355) were grown in 1918, and records of dates of blooming were made for comparison with the dates of blooming of the parent *N. Chinensis,* which is an unusually small and early maturing variety of *N. tabacum.* From the following table it is evident that the parent *N. Chinensis* blossomed somewhat earlier than the F_1 plants of the cross with Maryland Mammoth:

TABLE II

NUMBER OF DAYS ELAPSING FROM TRANSPLANTING TO DATE OF FIRST BLOOM OF F_1 PLANTS OF CROSS MARYLAND MAMMOTH ♀ × N. CHINENSIS ♂ AND PLANTS OF THE PARENT VARIETY OF N. CHINENSIS

Variety	Classes									
	45	47	49	51	53	55	57	59	61	63
N. Chinensis	8	5	11	2	10	1	6	0	2	5
Md. Mammoth ♀ × N. Chinensis ♂				1	14	1	14	2	1	11

In the cross Maryland Mammoth × White Burley, Mammoth Burley types have consistently appeared in the F_2 progenies, and have since remained true to Mammoth character. These have been crossed with a number of different types and varieties of *N. tabacum.* During the summer of 1918 considerable data were secured at Arlington, Va., showing the segregation of plants of Mammoth character in the F_2 of many crosses.

Let us first consider the behavior of different Mammoth types when intercrossed. In these lines the Maryland

Mammoth (narrowleaf type) has been crossed with Stewart Cuban (a giant type previously mentioned as originating in Connecticut in Cuban shade-grown tobacco), and also with a Mammoth Burley type, which was secured in the F_2 generation of the cross Maryland Mammoth × White Burley. In the cross Maryland Mammoth × Stewart Cuban, many plants of the F_1 generation were grown, all of which were of Mammoth habit of growth. Selections of these F_1 plants were grown and bred true to the Mammoth habit.

In the cross Maryland Mammoth ♀ × Burley Mammoth ♂ many F_1 plants were grown at Arlington, Va., in 1918. Of a total of 558 individuals, all were of Mammoth habit and of this number twenty-one were yellowish green like the normal White Burley variety, and 237 were full green in color like the Maryland Mammoth parent.

In a study of the reappearance of Mammoth types in the F_2 generation of crosses involving Mammoth and normal forms, several different combinations have been made. In one group both parents were of Burley type. In the second group one of the parents was normal green and the other of Burley type. In the third group both parents were green.

In the first group, involving Burley color in both parents, one of the parents was the Burley Mammoth secured in the F_2 generation of the cross Maryland Mammoth × White Burley. From the cross Mammoth Burley ♀ × ordinary White Burley ♂, 638 F_2 plants were grown, of which 158 were Mammoth. This is a very close approximation to the theoretical Mendelian ratio $638/4 = 159.2$, which should obtain in a cross involving two simple contrasted Mendelian characters.

From the cross White Burley type of 30A,[2] ♀ × Burley Mammoth ♂, 348 F_2 plants were obtained, of which eighty were of Mammoth habit of growth. This figure closely approximates the theoretical Mendelian ratio $348/4 = 87$.

[2] The type designated as White Burley type of 30A is a tall, vigorous Burley type originally obtained from the cross Connecticut Broadleaf × White Burley.

Of the total number of Mammoth plants, *i. e.*, 986, appearing in the F_2 of these crosses, only two were Green Mammoth, the rest being typically of Burley character. Whether these two exceptions represent mixtures or reversions can not be stated.

In the second group, one of the parents involved in the original cross was Green, the other being of Burley character.

From the cross Connecticut Broadleaf ♀ × Burley Mammoth ♂, 305 F_2 plants were grown, of which sixty-nine were of Mammoth habit. This approximates the theoretical ratio $305/4 = 76.2$. From the cross Maryland Mammoth ♀ × White Burley type of 30A ♂, 152 F_2 plants were grown, of which forty were of Mammoth habit. This figure is very close to the theoretical ratio $152/4 = 38$. Of the total number of Mammoth plants, *i. e.*, 457, which appeared in the two crosses Connecticut Broadleaf ♀ × Burley Mammoth ♂ and Maryland Mammoth ♀ × White Burley type 30A ♂, only two were of Burley color, the rest being green.

We will now consider the third group, which involves normal green color in both parents.

From the cross Connecticut Broadleaf ♀ × Maryland Mammoth ♂, 175 F_2 plants were grown, of which thirty-nine were of Mammoth habit.

From the cross Maryland Mammoth ♀ × Yellow Pryor ♂, eighty-three F_2 plants were grown, of which twenty-five were Mammoth.

From the cross Little Dutch ♀ × Maryland Mammoth ♂, 119 F_2 plants were grown, of which twenty-eight were Mammoth. A total of 377 plants were grown in these crosses, of which ninety-two were Mammoth plants. This is a very close approximation to the expected ratio $377/4 = 94.2$.

Considering all the crosses in the three groups involving the Mammoth character in one of the parents a total of 1,820 F_2 plants were grown, of which 439 were of Mammoth character. This is a fair approximation to the

expected ratio 1820/4 = 455, if the Mammoth habit behaved as a simple Mendelian character in contrast with the normal blossoming habit.

From these data it would appear that the Mammoth character is recessive in its inheritance and reappears in the F_2 generation in numbers approximating closely the expected ratio for a simple Mendelian recessive.

The Origin and Behavior of a New Mammoth Type of Tobacco in a Line Descending from a Species Hybrid

In an earlier paragraph it has been mentioned that the Maryland Narrowleaf Mammoth and a Burley Mammoth appeared in the F_2 generation of certain crosses. In the writer's experience a giant type appeared in third generation plants descending from a species cross.

In 1914 the blossoms of a first generation plant of the cross Connecticut Broadleaf (pink) ♀ × Giant Red flowering (carmine) ♂ were pollinated with the pollen of *Nicotiana sylvestris* (white).[3] Although first generation plants of crosses between the species *N. tabacum* and *N. sylvestris* are likely to be sterile, or nearly so, considerable fertile seed were obtained from F_1 generation of this particular cross. In the second generation there was a noticeable segregation into plants with pink, white and carmine blossoms. The size and shape of the blossoms of the plants of the F_2 generation were also very variable and various abnormalities were noted. Some plants were completely self-sterile and others produced blossoms with supernumerary petals. A number of plants producing the largest and finest carmine-colored blossoms were selected for further inheritance studies. The progenies of two of these mother plants, nos. 9 and 12, were grown in the field at Arlington, Va., during the season of 1916.

The mother plant, no. 9, proved to be heterozygous, breaking up into carmines and pinks, approximating the theoretical ratio of three carmines to one pink. All the plants of this line were normal in size and habit of growth.

[3] The so-called Giant Red flowering tobacco sold by seedsmen for ornamental purposes, is only a variety of *N. tabacum* with deep carmine blossoms.

The sister plant, no. 12, which proved to be homozygous for carmine, behaved differently, giving rise to a progeny of plants which were very variable in height.[4] A number of these plants appeared to possess the Mammoth habit of indeterminate growth and gave no evidence of blossoming. On October 26, 1916, the heights of the plants, all of which had blossomed except those of Mammoth habit of growth, were as follows:

TABLE III.

HEIGHTS OF THE PLANTS IN THE PROGENY OF SISTER PLANT NO. 12

	Height classes		
	3 to 5 ft.	5 to 7 ft.	7 to 9 ft.
Number in class....	12 (blossomed)	16 (blossomed)	3 (Mammoth)

The shortest plants in this progeny were first to blossom and produced an average of only 20 to 25 leaves, including the first bald sucker. Other plants of intermediate heights blossomed considerably later and produced an average of 35 to 40 leaves, including the first bald sucker. Those plants of Mammoth habit of growth which showed no indications of blossoming had produced considerably more than 40 leaves.

Two of these Mammoth plants, nos. 12 (a) and 12 (b), each seven feet in height, were transplanted in the greenhouse October 21 without cutting them back. Both plants blossomed December 8, producing carmine blossoms. Plant no. 12 (a) had produced 70 to 75 leaves, not including many bract-like leaves below the flowerhead. Plant no. 12 (b) produced 60 to 65 leaves, including all small ones below the flowerhead.

In addition to these two Mammoth plants the seed of several of the taller sister plants, nos. 12 (c) and 12 (d), in class 2, which had blossomed late, producing 35 to 40 leaves, were saved separately. The progenies of all were grown in the field at Arlington Farm, Va., in 1917. A

[4] The leaves of the mother plant no. 12 were characterized by coarse, thick, broad and rounded blades abruptly contracted at the base to a long, almost naked or slightly winged petiole. This striking type of leaf has remained constant in the progeny of no. 12, and also in the progenies of no. 12 (a), 12 (b), 12 (c) and 12 (d), descending from this mother plant.

total of 60 plants was grown from the Mammoth mother plant, no. 12 (a), all of which were of Mammoth type, with an average height of seven to seven and a half feet. On September 11 a few of the tallest plants were eight feet in height. On this date an average of 50 to 55 leaves had been produced and none showed any evidence of blossoming. A progeny of 60 plants (see row 38A, 1917) was also grown from the Mammoth mother plant, no. 12 (b). On September 11 these plants averaged six and a half to seven feet in height and resembled the progeny of no. 12 (a) in all respects except that they were not quite as tall.

From the mother plant, no. 12 (c), which was one of the late blossoming plants, producing an average of 35 to 40 leaves, 49 plants were grown. On September 13 the heights of 48 of these plants and their blossoming habits were noted as follows:

TABLE IV

HEIGHTS OF 48 PLANTS IN THE PROGENY OF MOTHER PLANT NO. 12 (c) SELECTED FROM CLASS 2, OF TABLE III

	Height of classes					
	5 to 7 ft.		7 to 9 ft.		1 to 11 ft	
	Normal	Mamm.	Normal	Mamm.	Normal	Mamm.
Number in class ..	2	2	20	12	12	0

The height of one plant which blossomed was not obtained and is not included in the table.

In this progeny of 49 plants it is evident that 14 plants possessed Mammoth characteristics of continuous growth and showed no evidence of blossoming, while 35 plants, some of which were of giant stature, blossomed. From the late blossoming mother plant, no. 12 (d), a progeny of 48 plants was grown. The heights of 42 of these plants were also measured on September 13 and their blossoming habits noted as follows:

TABLE V

FREQUENCY DISTRIBUTION OF HEIGHTS OF 42 PLANTS IN PROGENY OF MOTHER PLANT NO. 12 (d) SELECTED FROM CLASS 2 OF TABLE III

	Height of class							
	3 to 5 ft.		5 to 7 ft.		7 to 9 ft		9 to 11 ft.	
	Normal	Mamm.	Normal	Mamm.	Normal	Mamm	Normal	Mamm.
Number in class	0	1	17	0	19	0	4	1

Six other plants were grown in this progeny which are not included in the table since their heights were not obtained. All blossomed, however.

In addition to these individual progenies of the sister plants, nos. 12 (a), (b), (c) and (d), selected from the progeny of the mother plant, no. 12, in 1916, a mixed lot of seed was harvested from several other sister plants which had blossomed. Fifty-six plants were grown from this mixed lot of seed, all averaging six to six and a half feet in height, and all blossoming. In this lot of plants there were no indications of Mammoth types and so far as could be determined with the eye, no intermediate forms were present.

From the inheritance behavior of the sister plants, nos. 12 (a), (b), (c) and (d), it is evident that pure Mammoth types, breeding true, and intermediate inconstant types appeared simultaneously in the progeny of the original mother plant, no. 12. These intermediate plants behaved as hybrid forms, in that they gave rise in their progeny to a certain percentage of typical Mammoth, non-blossoming types. Since the progenies of the two sister plants, nos. 12 (c) and (d), were handled under similar conditions from the time the seed were sown, it is evident that the mother plant, no. 12 (c), yielding 14 Mammoth plants in a total of 49 plants, was considerably more prolific in Mammoth individuals than the sister plant, no. 12 (d), which yielded only two Mammoth individuals in a total of 48 plants.

It is of interest to note that Lodewijks (1911) in working with tobacco in Java, has observed the occurrence of Mammoth types which breed true and also intermediate or inconstant races which break up into Mammoth or Giant forms approximating the theoretical Mendelian ratio of 25 per cent.

Lodewijks regards these inconstant races as hybrid mutations and states the results of his investigations as follows, a translation of which will also be given:

TRANSLATION

I. Occasionally giant plants which breed true to type occur in Vorstenland tobacco.

II. Evidently giant intermediate races also occur.

III. In my experiments I obtained either an atavist of an inconstant intermediate race or a hybrid-giant.

IV. As none of the giant plants in my experiments have reached the flowering stage, it is not certain which of the two mentioned possibilities is the chief. It would seem to be the latter, however, as seed of the few-leaved mother plant of the second generation produced exclusively plants while seed of the many-leaved plant produced nearly 25% giant and many-leaved and few-leaved plants.

V. It is probable, therefore, that a second instance is present of a mutation arising as a hybrid.

Honing (1914), in his studies of the aberrant types occurring in Sumatra and Java tobacco, states that in some instances 100 per cent. of the progeny of normal plants were of the Mammoth type. According to Honing even the Mammoth plants were not always constant in their inheritance, and intermediate races were also present.

From Lodewijk's observations in Java, and the writer's observations at Arlington Farm, Va., it is evident that intermediate races, as well as Mammoth types which breed true, may appear in a progeny. Concerning the actual mode of origin of these intermediate and Mammoth races nothing definite is known. Hayes and Beinhart (1914), speaking of the origin of a Mammoth Cuban type in Connecticut in 1912, say:

This mutation must have taken place after fertilization, *i. e.,* after the union of the male and female reproductive cells. If the mutation had taken place in either the male or female cell before fertilization, the mutant would have been a first generation hybrid, and would have given a variable progeny the following season.

They assume that if one gamete alone were affected, a progeny of hybrid character would have resulted, but if we assume that one gamete can become so affected, it is quite as reasonable to assume that both may sometime be changed in the same manner. If such were the case, Mammoth plants breeding true to this indeterminate habit of growth would be expected.

If, as Lodewijk finds, intermediate races behave as true Mendelian hybrids, producing the theoretical ratio of 25

per cent. true Mammoth plants which breed true, there is strong reason to believe that the change responsible for Mammoth habit of growth has affected one gamete only. If this gamete unites with a normal gamete, then the simple Mendelian ratio would follow, just as in the case of an artificial cross between gametes produced by a Mammoth plant and those of a normal plant. In the one case a portion or all the gametes bearing the Mammoth character are produced by a normal plant. In the other case, Mammoth plants themselves produce gametes with potential Mammoth characters. In the experience of Honing, normal plants have even produced progenies containing 100 per cent. mammoth plants. This behavior would indicate that all the gametes produced by a mother plant may sometimes become modified to express the Mammoth habit of growth. Although Honing has observed the complete disappearance of a line of Mammoth plants which gave rise to progenies of blossoming plants, this behavior has not been definitely observed in this country except as a response to obscure environmental conditions. It is possible that the behavior of Honing's inconstant Mammoths is of this nature rather than an internal gametic change, permanently affecting the heredity of the Mammoth feature. Until this question is more definitely settled, Honing's inconstant Mammoth can not be disposed of.

Since inconstant, intermediate plants behaving as Mendelian hybrids with respect to Mammoth character, and sister plants of pure type are known to arise suddenly in the same progeny, there is reason to believe that the change responsible for Mammoth behavior may affect one or both gametes, as the case may be. This inconstant behavior of these mutant hybrids is particularly significant since it appears in every way similar to the actual behavior of a controlled cross between a Mammoth and a normal plant. Of course, if it is possible for one or more gametes produced by a normal plant to become so modified as to originate a hybrid-mutant or a pure line mutant,

then it is quite as probable that all the gametes in a single blossom, or the gametes produced by all the blossoms of a normal plant, may become so modified. Honing's observations at least would indicate that this does occur.

In those instances where an occasional Mammoth appears in the progeny of a normal plant, it is usually assumed that the change responsible for the Mammoth character was associated in some way directly with the gametes themselves. In those instances where many or even all the plants in the progeny of a normal plant produce Mammoths, the question becomes more involved and difficult of interpretation. It is very difficult to see how all the gametes of a normal plant can become simultaneously modified to produce by their union Mammoth plants, unless we assume that the change takes place at some stage preceding the development of the gametes. Should the change take place in a mother cell of the anther preceding tetrad formation, *i. e.*, by the addition or subtraction of some factor in the chromosome material, it is reasonable to suppose that the four pollen grains resulting from the division of this mother cell may be similarly affected, and bear the Mammoth character. It is possible, however, that the change may take place very much earlier, so that a part or even all the sporogenous cells will be affected. If this condition occurred, it is easy to see how great numbers or even all the pollen grains arising from their division would bear the Mammoth character. Since the development of the megasporangium is in every way parallel to the development of the microsporangium or anther, similar changes would affect one or more egg-cells, depending upon whether the change responsible for Mammoth character took place immediately in the egg-cell itself, in the mother cells, or very much earlier, so that all the sporogenous cells, and hence all the egg-cells arising from them, are affected. Such changes affecting great numbers or all the gametes in a single flower, or even in the entire flower head itself, would produce the phenomenon of a more or less complete acquirement of Mam-

moth character in the progeny of a normal plant. It may be stated here that East (1917) has offered the same suggestion concerning the origin of variations in cell-divisions preceding the formation of the gametes themselves.

The Production of New Mammoth Forms by Hybridization

Two Mammoth types of tobacco are now grown commercially in the United States, the Maryland Narrowleaf Mammoth in Maryland, and to a lesser extent the Stewart Cuban in the Connecticut Valley. Promising Mammoth types have also originated in Havana Seed tobacco in Connecticut. Beinhart (1918, however, in a brief discussion of the occurrence of Mammoth types in the Connecticut Valley, states that practical methods of seed production and special cultural methods must be worked out before the Stewart Cuban Mammoth and the Havana Seed Mammoth can be successfully grown on a commercial scale. Although these Mammoths originated spontaneously from commercial types, there is every reason to believe that valuable new types can be secured by crossing with the ordinary commercial types of tobacco. Since in crosses with ordinary varieties gigantism is recessive in its inheritance, the problem of producing new giant types by hybridization and recombination has not been difficult. Several Mammoth types have already been secured in crosses with Connecticut Broadleaf, Little Dutch and White Burley. If by this means it is possible to combine the habit of gigantism, which insures greatly increased yields, with the desirable quality characteristics of ordinary varieties, very valuable commercial types can be obtained.

Summary

1. Gigantism has occurred in several different commercial varieties of tobacco, including Maryland types, Cuban, Connecticut Havana and Sumatra. It has also been associated with certain varietal crosses and species crosses.

2. Not only giant or mammoth types which breed true, but intermediate or hybrid types occur spontaneously which subsequently give rise to a greater or less proportion of mammoth forms.

3. In crosses with normal varieties the mammoth character is recessive, and F_1 plants invariably blossom. The F_1 plants average a somewhat higher leaf number than the normal parent which entered into the cross.

4. In the F_2 generation mammoth plants occur in proportions approaching the theoretical ratio of 25 per cent. obtaining in a single Mendelian cross involving two contrasted unit characters.

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